The (simple) Case for a New 5G Air Interface… and a few other things

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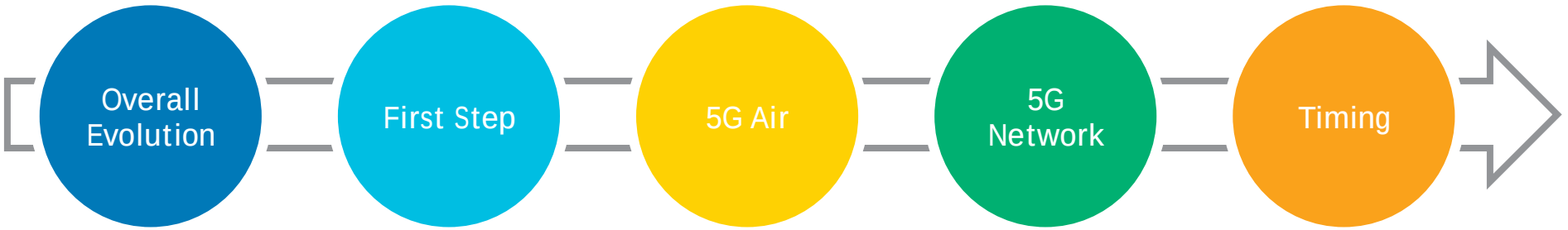
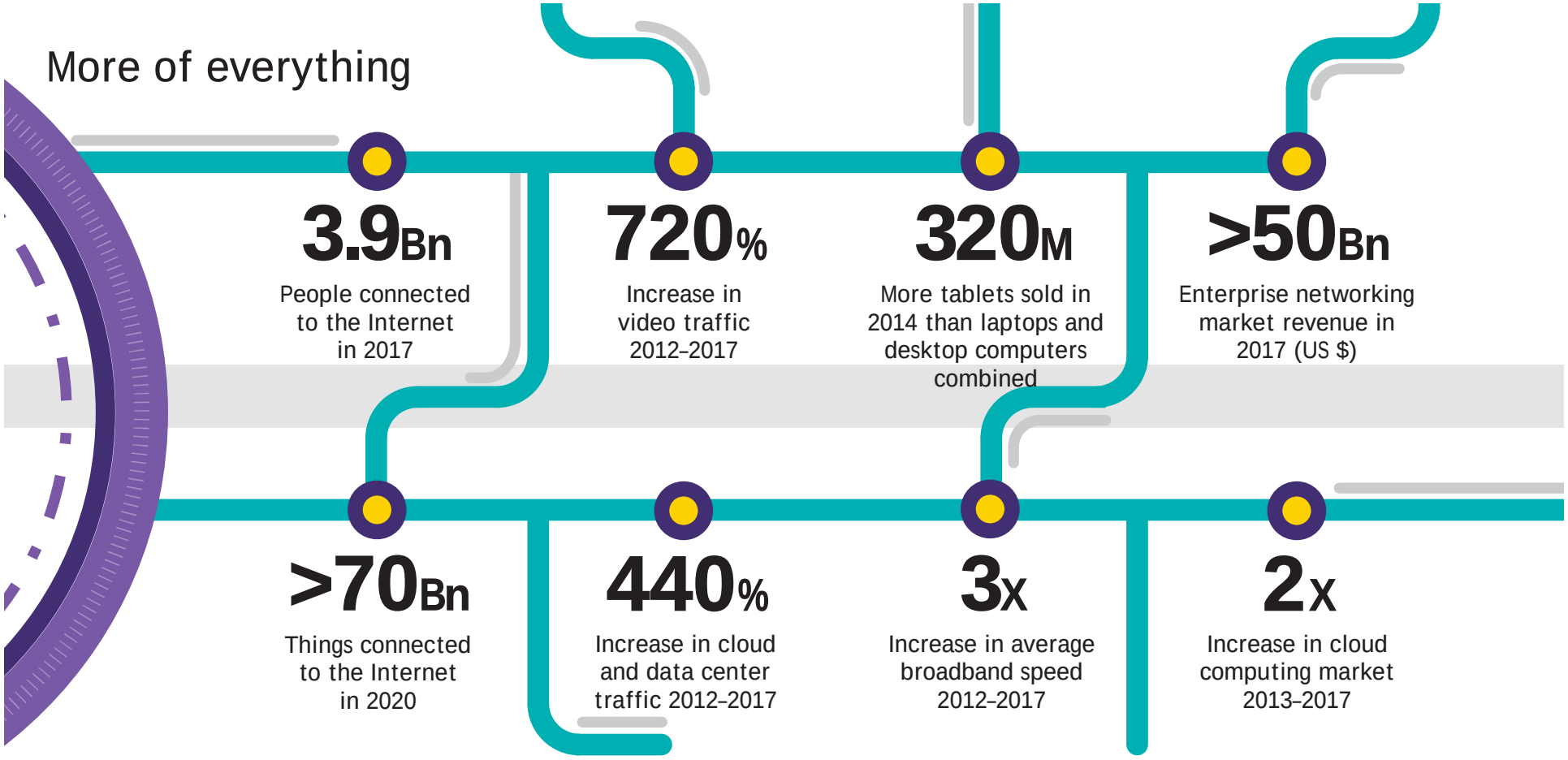
20150508 Washington D.C.

Agenda

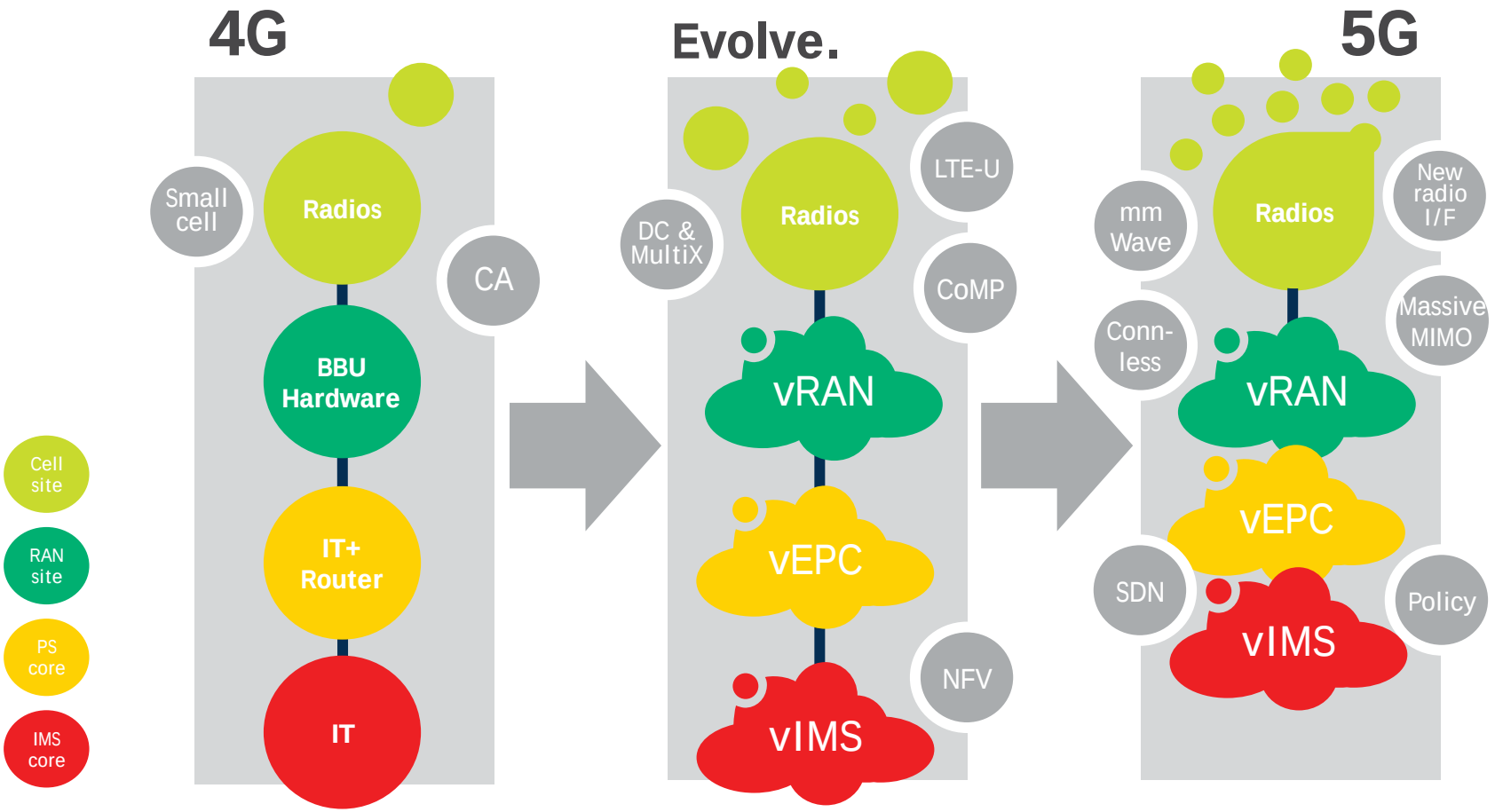


More of everything



IoT key requirements

Factor	Requirements – low end	Requirements – high end	Range
Peak data rate	<100 bits/s UL (e.g. smart metering)	> several Mb/s UL (e.g. security cameras)	10000
Latency	>1 s (e.g. smart metering without control)	< 10 ms (e.g. ITS Intelligent Transportation Systems - ITS)	100
Usage	<1 event/day (e.g. intrusion alarm)	"continuous" (e.g. security cameras)	∞
Coverage	Normal (e.g. outdoor devices)	+20 dB (e.g. indoor devices located in basements)	100
Mobility	"none" (stationary devices)	"seamless" (e.g. ITS devices)	∞
Device cost	"not an issue"	<4$ for e.g. smart meters	10
Battery lifetime	"N/A" (e.g. remotely-powered devices)	>10 years (e.g. smart meters)	∞



Every success has its network

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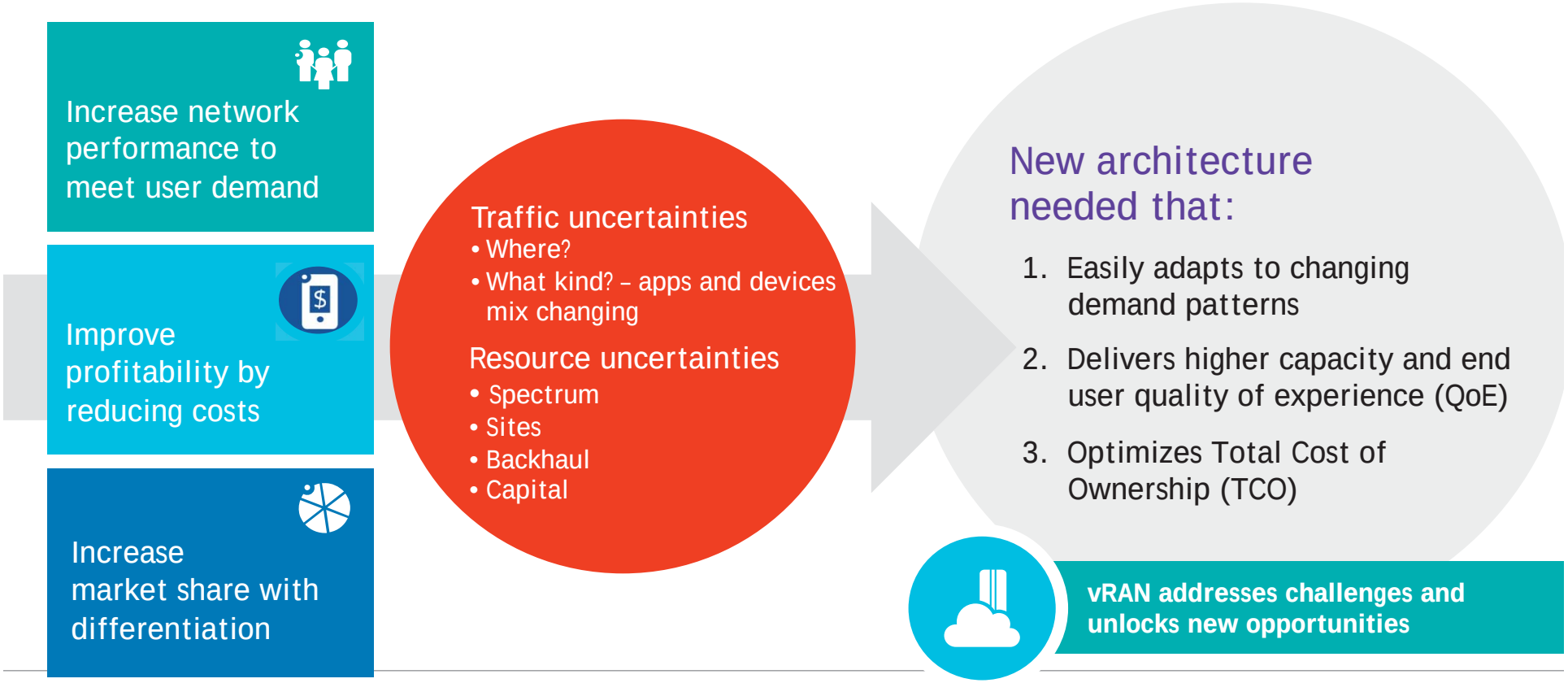
Operator drivers for a new architecture



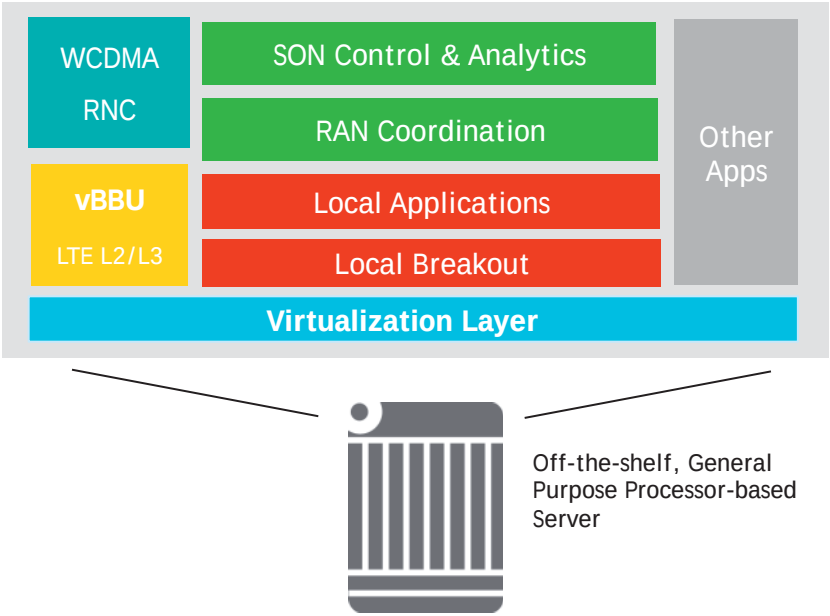
What is a vRAN?

vRAN

- Virtualized, centralized, and pooled functions hosted in the RAN
- Includes vBBU function hosting L2/3 processing of LTE base station
- Implements additional functions and applications for control, performance and delivery optimization

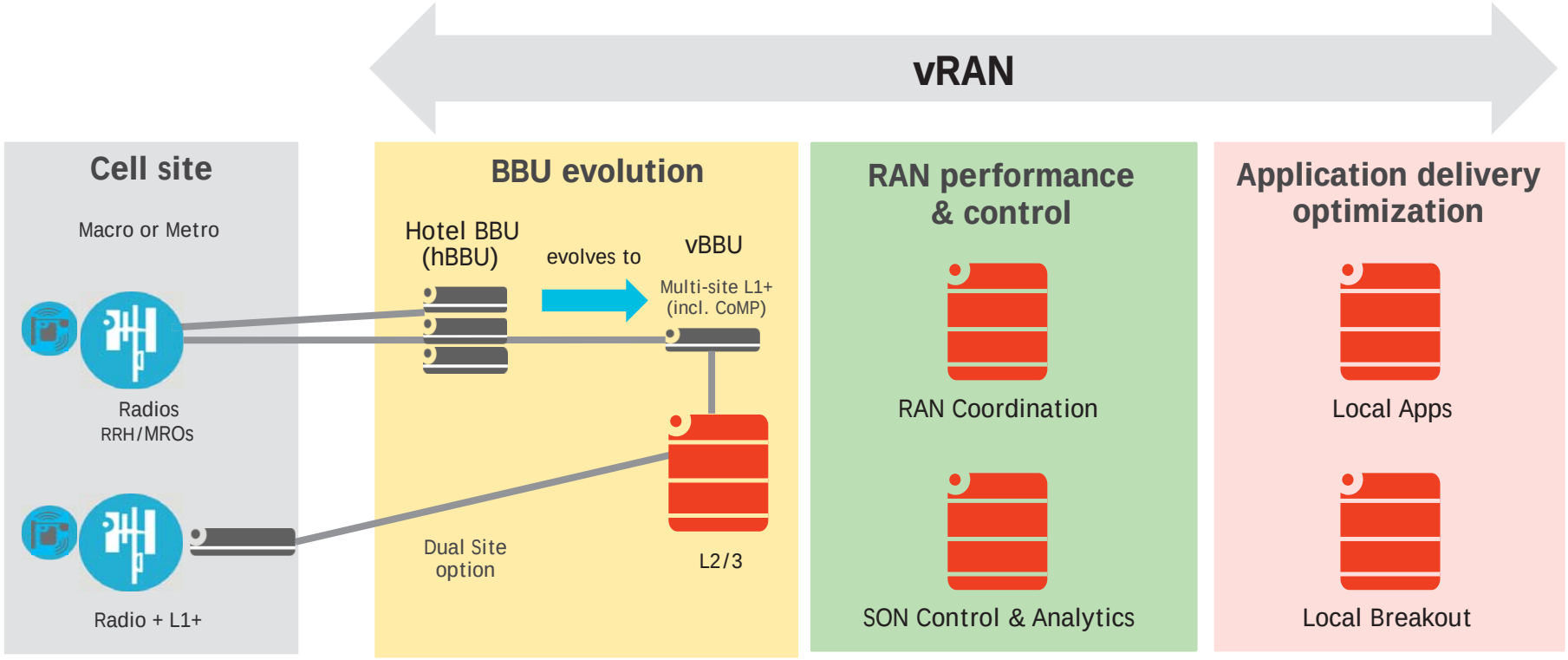
Virtualization (applications abstracted from hardware)

- Continuous cost/performance benefits from simplified operations and higher reliability
- Flexible capacity: Application scaling separated from hardware scaling
- Capability to host different virtualized functions/ applications on the same hardware platform



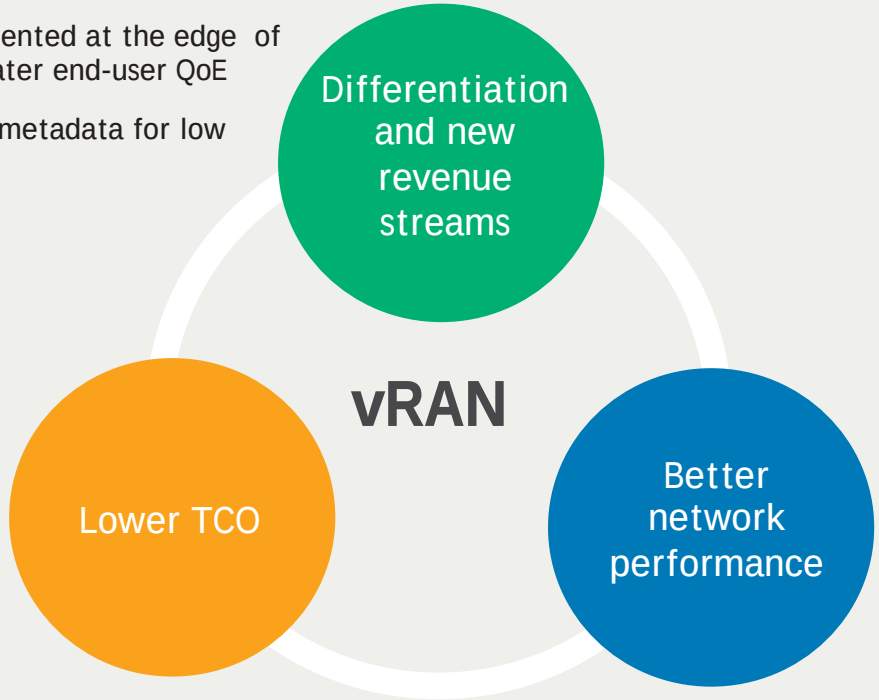
vBBU: virtualized baseband unit

High level vRAN architecture
Virtualizes ran functions and optimizes hosting of new functions



Benefits of vRAN

- Applications implemented at the edge of the network for greater end-user QoE
- Fast access to local metadata for low latency applications



- Simplified site acquisition, build and upgrade
- Hardware economies of scale
- Simplified operations
- Lower cost redundancy

- Better performance using cell coordination features
- Easier load balancing across centralized cells
- Applicable to macro, metro sites and HetNets

Efficient use of hardware with vBBU

DRIVERS

Cell site BBU must meet peak load:

- Mobile apps driving increasingly peaky traffic
- IoT devices introducing new traffic patterns
- HetNets driving increasingly dynamic load per cell

BENEFITS

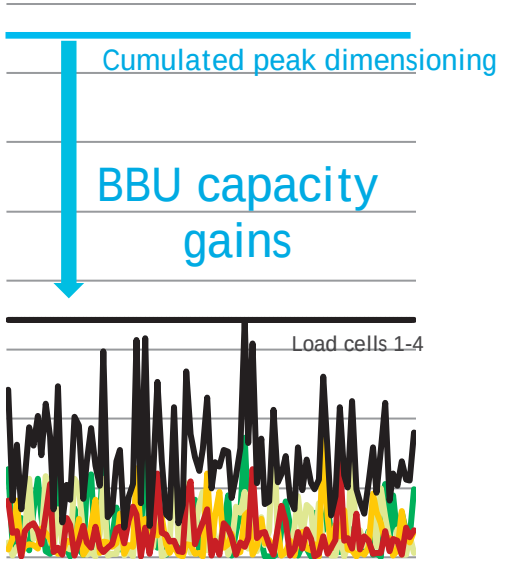
Virtualizing BBU enables scaling and pooling among cells

- Statistical dimensioning
- Pooling of a larger amount of cells
- Scaling of user load sensitive L2/ L3 part of baseband processing
- Tuning of active user capacity between macro and metro cells

CELL SITE BBU MUST MEET PEAK LOAD

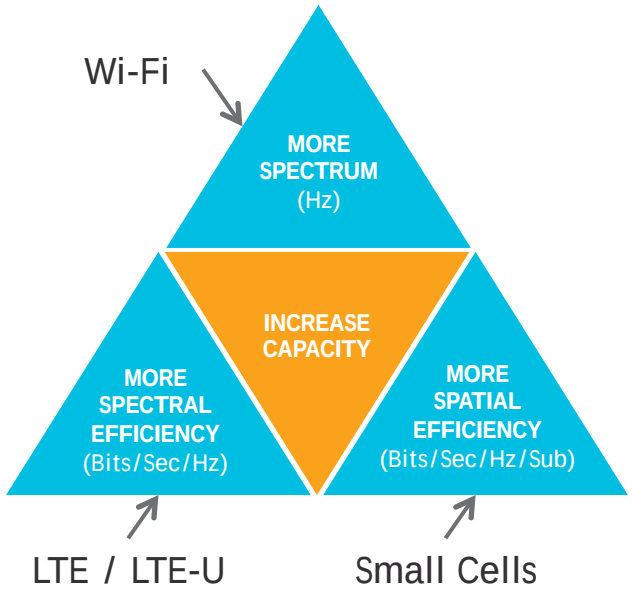
Statistical gains delivered by pooling

VBBU ENABLES SCALING & POOLING AMONG CELLS



Small Cells and WiFi: Wireless Unified Networks for near-wireline QoE

Multi-RAT and LTE-U



- Small cell innovation (home, enterprise, metro)
- LTE-Unlicensed (LTE-U) / Licensed Assisted Access (LAA)
  - Dynamic co-existence of Wi-Fi and Cellular (LTE)
- "Boost"
  - Blending of Wi-Fi and Cellular (LTE & W-CDMA)

Small Cells

Site Challenge: Integration in advertisment panels

MICROWAVE BACKHAUL

OPTIONAL

ONE OR TWO COMPACT METRO CELL OUTDOOR

HIDDEN BETWEEN THE TWO ADVERTISING PANNELS FOR MULTI-OPERATOR USE

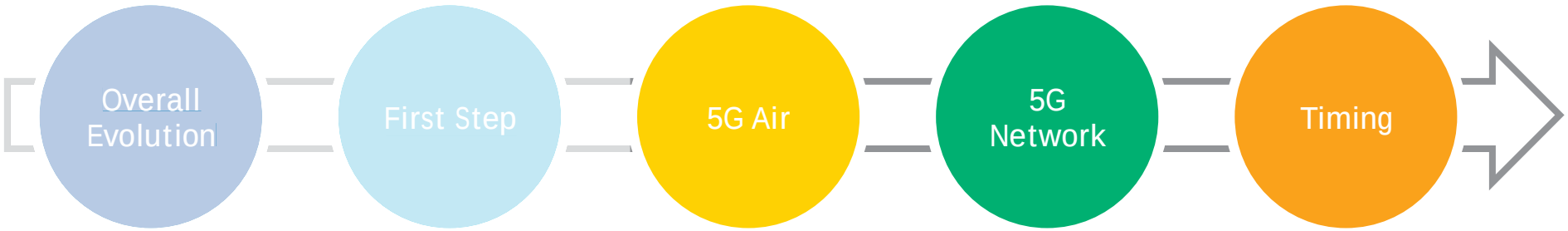
EXTERNAL ANTENNAS

HIGH ENOUGH FOR EXCELLENT PERFORMANCE

Wi-Fi ACCESS POINT

MULTI-OPERATOR LTE AND Wi-Fi CONNECTIVITY WITH MICROWAVE BACKHAUL

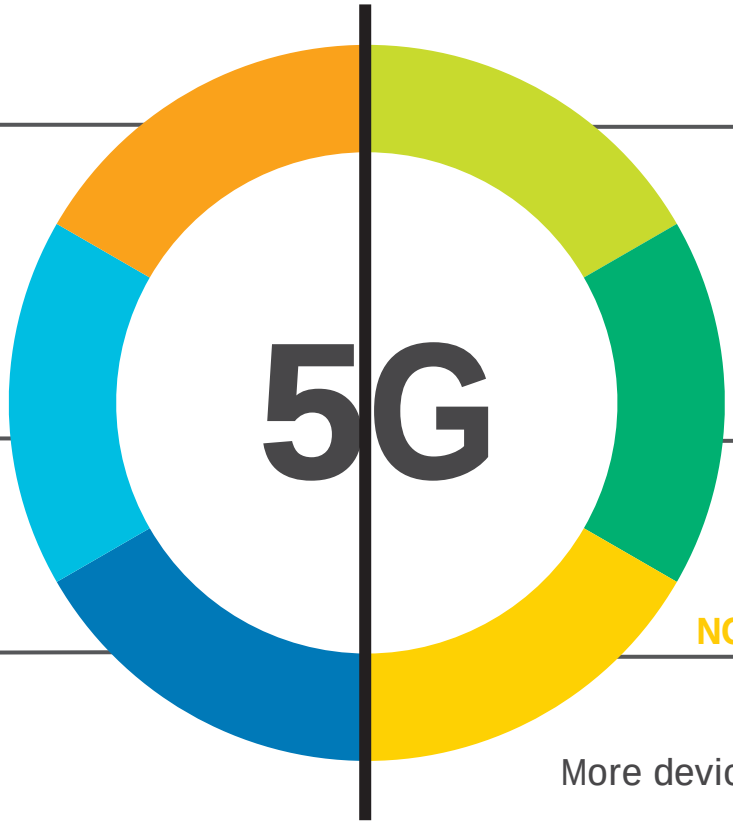
Agenda



9 Key use cases @NGMN

Use case family	Example use case	Key technical requirement
Broadband in dense areas	Pervasive video	Massive spectrum on small cell pushing need for new “high” band to achieve traffic density of up to 750 Gb/s per km2 in dense urban
Broadband everywhere	50 Mb/s everywhere	Significant improvement to cell edge bitrate to offer consistent user experience at target bitrate over 95% locations for 95% of time
	Ultra-low cost networks	Flexible radio parameters for cost reduction when offering limited services (<10 Mb/s, >50ms, <20 Device/km2)
Higher user mobility	High speed train	Flexible radio parameters for speeds up to 500 km/h
Massive Internet of Things	Sensor networks	Connectionless service to offer scalable solution for device densities of up to 200kDevice/km2 and extended battery life
Extreme real-time	Tactile internet	Flexible radio parameters for low latency down to 1 ms
Lifeline	Natural disaster	High availability and service recovery resilience mechanisms to ensure availability of basic communications (voice, text, etc.) with large battery life
Ultra-reliable	Public safety	High reliability rates up to 99.999% (5 nines) implying need to eliminate single points of failure from network design
Broadcast like	Broadcast services	Reuse of SFN techniques from LTE to offer efficient wide area service delivery

Where does 4G stumble? = 6 requirement drivers for 5G



BROADBAND
Massive traffic capacity
Reduce Cost
Spectrum efficiency
Access new spectrum

INNOVATIVE SERVICES
Flexible bearer design
3rd party policy

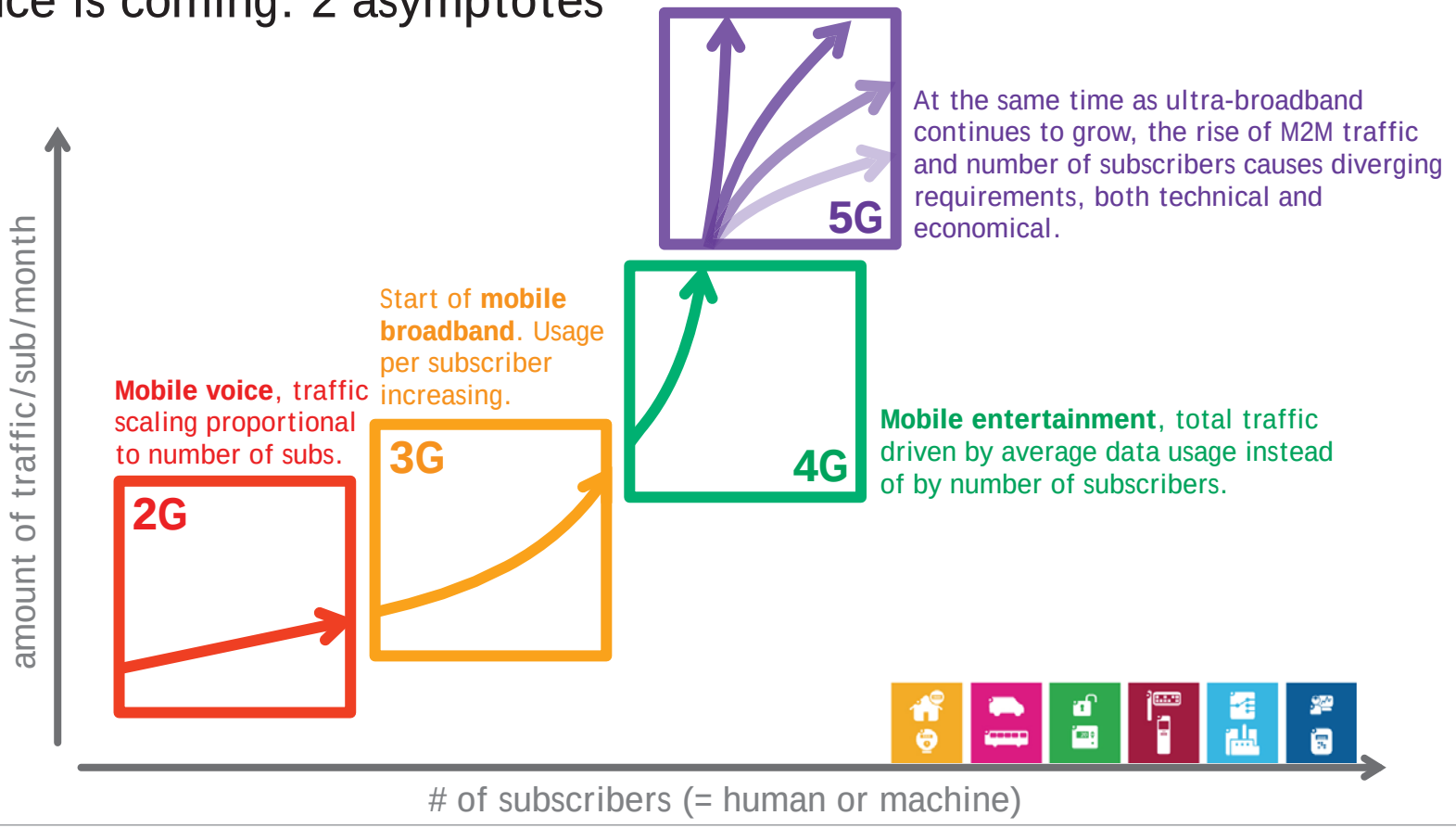
EXTREME DENSITY
Massive user density
User content

MISSION CRITICAL
Very low latency
High reliability
High availability
Security

BATTERY LIFE
Signaling reduction
Energy optimization

NON TRADITIONAL DEVICES
Short packet
Sporadic access
More devices and more device types

A divergence is coming: 2 asymptotes

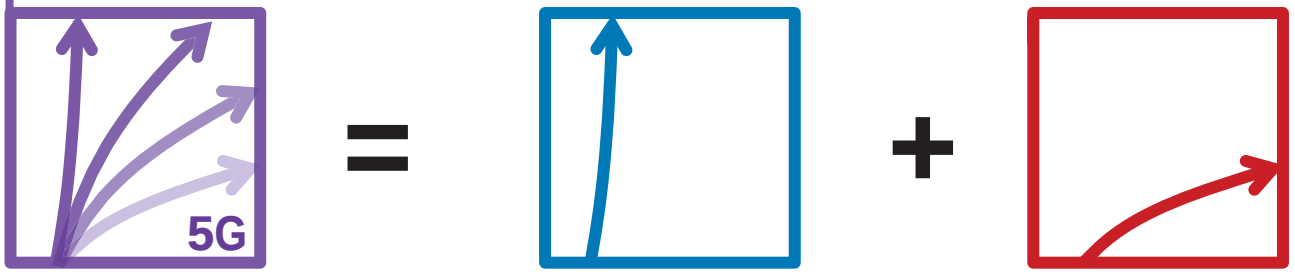


Driving vision

5G will be a **unified** ecosystem that serves both tradional as well as potential new applications like drones, real time video surveillance, mobile augmented and virtual reality, IIoT…

Ultra-narrowband = the evolution of sensing, command and control = a network that serves:

- Machine-2-Machine: sensors & control (latency!), exchanges between devices or applications (mobile devices, gateways, …) .

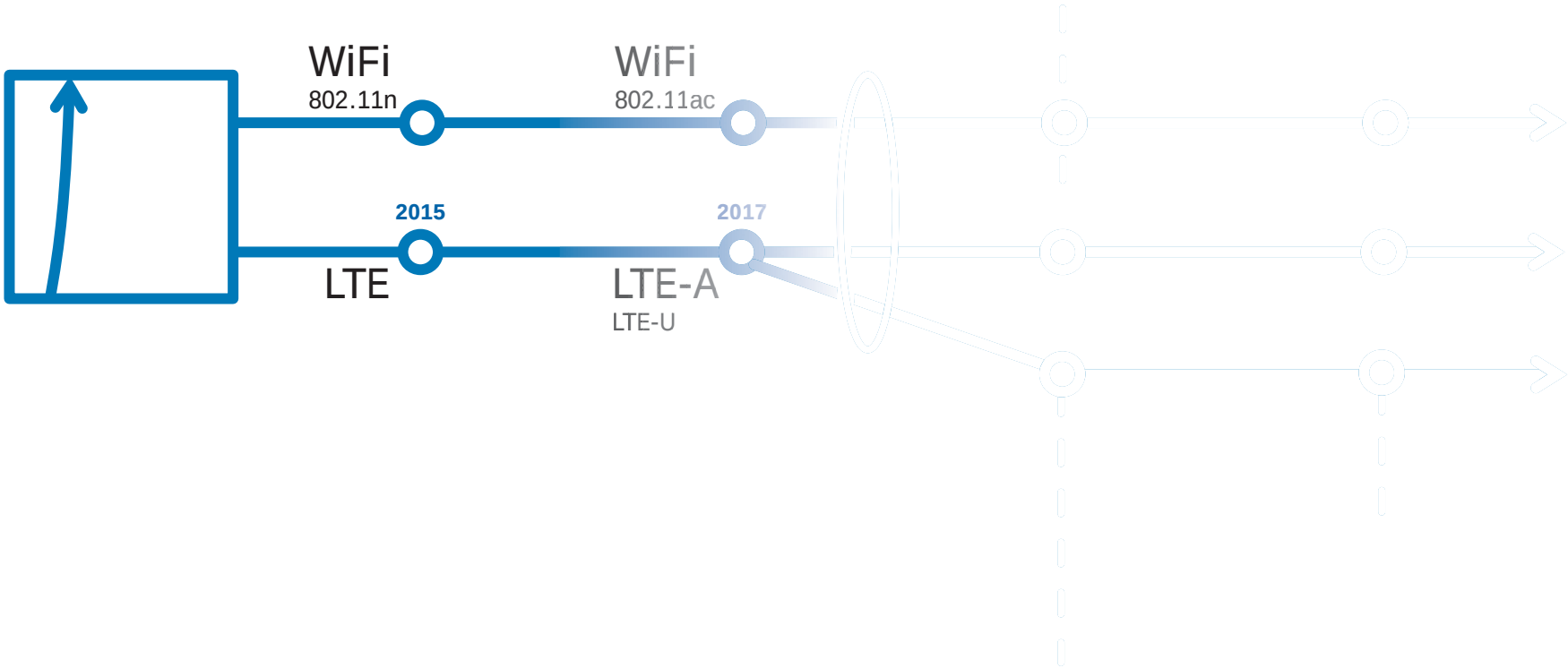


Ultra-broadband = the evolution of communications and entertainment = a network that serves:

- Human-2-Human: communications, be it voice or video
- Human-2-Machine: photos, video, upload to the cloud
- Machine-2-Human: mobile entertainment; video, games, internet

Technology evolution

The broadband scenario is “clear”



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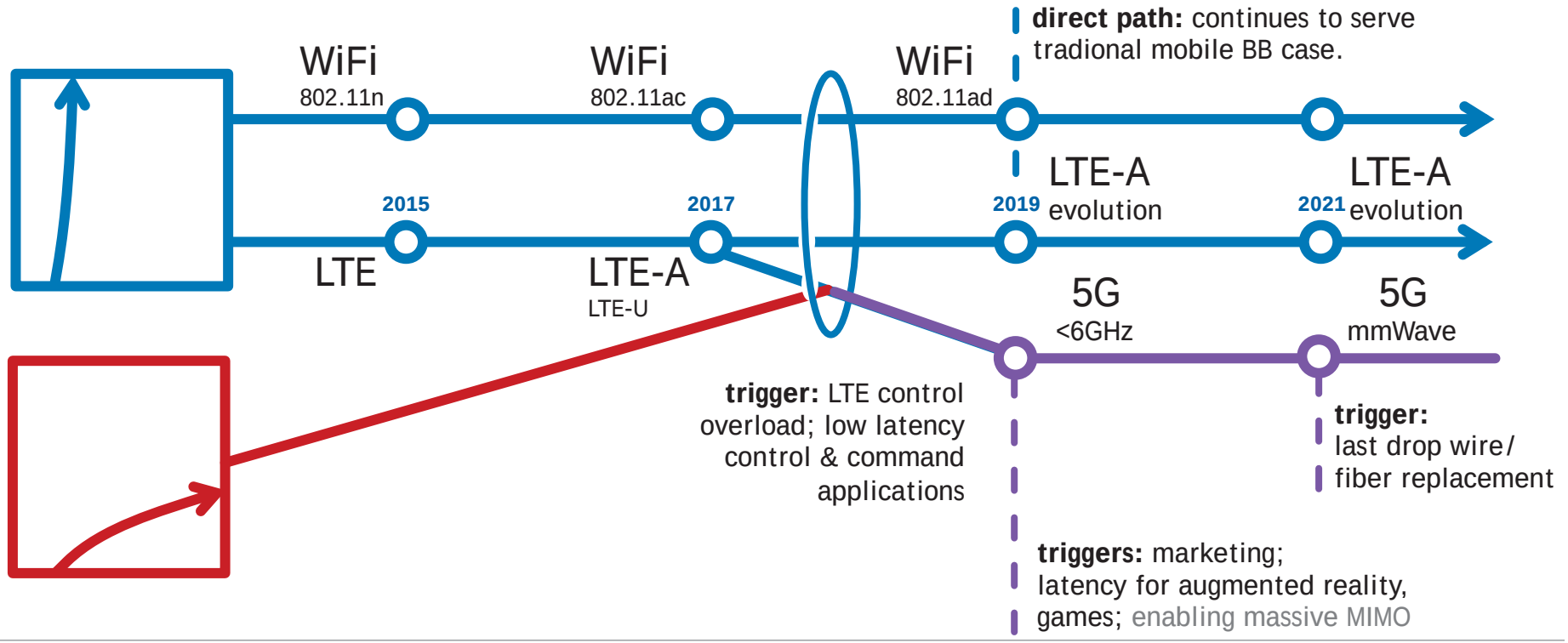
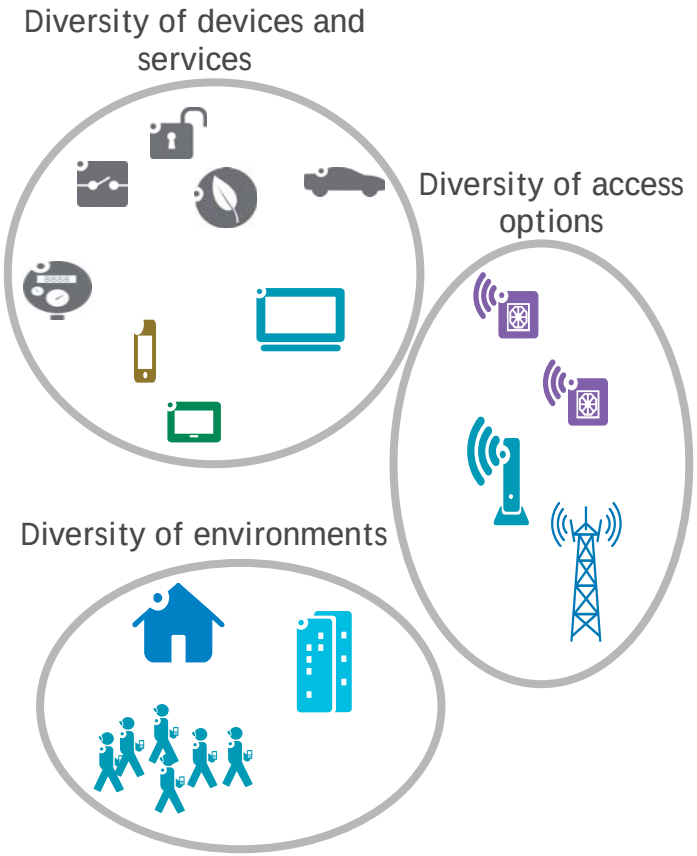
Technology evolution

The broadband scenario is “clear” – the narrowband is what we need to agree on !



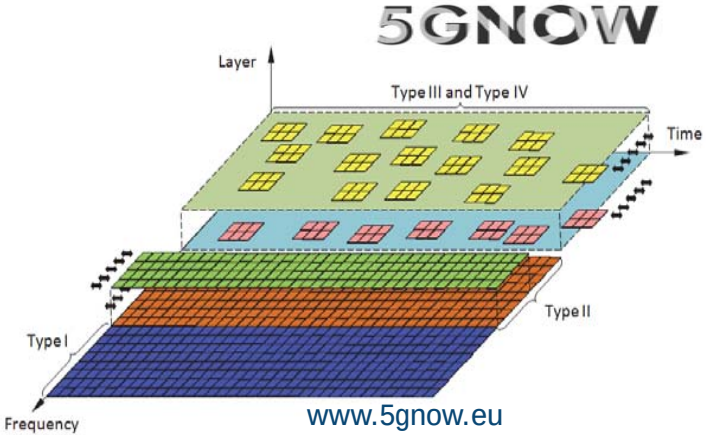
5G Radio: New air-interface needed

- Unified framework for multiple services with different requirements
  - Spectral efficiency improvement for short bursts
  - High battery life for short packet IoT devices
  - Very low latency for critical applications
  - Acceptable performance out to cell edge
- Flexibility to optimize the parameters for different situations
  - Service needs (latency, activity, performance)
  - Vehicle speeds (static/nomadic to 500 km/hr)
  - Environments & Propagation (indoor/small cell/macro in urban/rural)



5G radio: Adding contention access within air interface

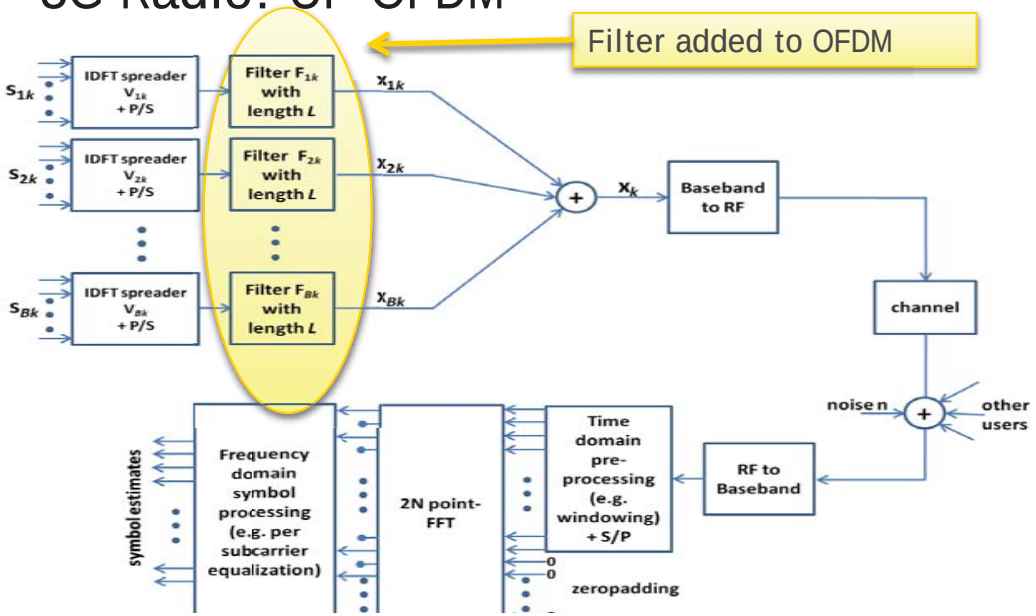
- Challenge:
  - Combine broadband and small packet traffic
  - Be resource efficient (energy, spectrum, network)
  - Allow for low overhead , low complexity, simple terminals
  - Offer high reliability & low latency options
  - Add new contention mode to support connectionless services for bursty traffic

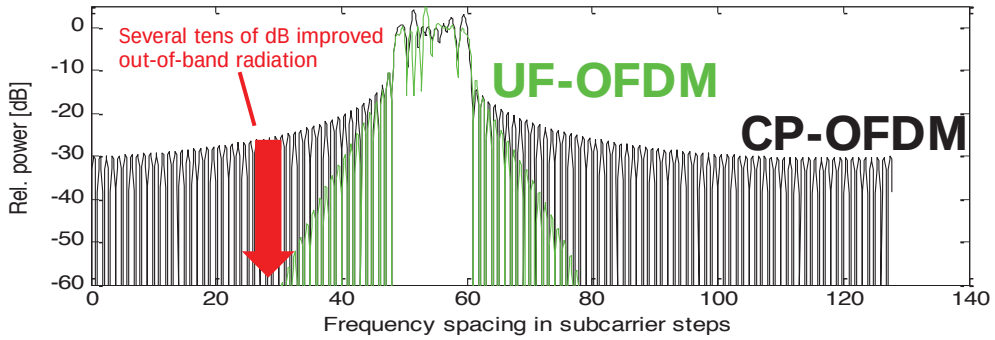


Traffic Type	Synch?	Access Type	Properties
I	closed-loop	scheduled	classic high volume data services
II	open-loop	scheduled	HetNet and/or cell edge multi-layered high data traffic
III	open-loop	sporadic, contention-based	few bits, supporting low latency, *e.g. smartphone apps*
IV	open-loop/none*	contention-based	energy-efficient, high latency, few bits

*: none for maximal energy savings at Tx, open-loop for reduced complexity at Rx

5G Radio: UF-OFDM

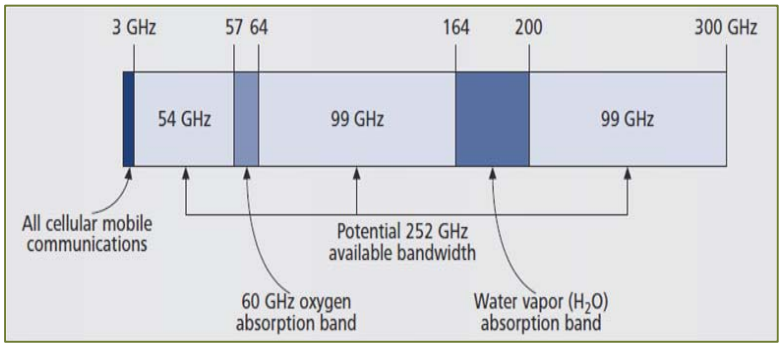




- Designed to meet new requirements
  - Contention based access for connection-less services
  - In-band optimization to devices and services
  - Higher capacity
- Universal Filtered OFDM (UF-OFDM)
  - New filter stage applied per sub-band
  - Cyclic prefix replaced by filter time response
  - More tolerant to power and timing errors
  - Reduced guard band requirements
  - May re-apply huge knowledge base of LTE processing

[1] F. Schaich, T. Wild, Y. Chen, "Waveform contenders for 5G - suitability for short packet and low latency transmissions" , VTC'14
[2] 5GNOW deliverable D3.2

5G Radio: High band to add massive capacity

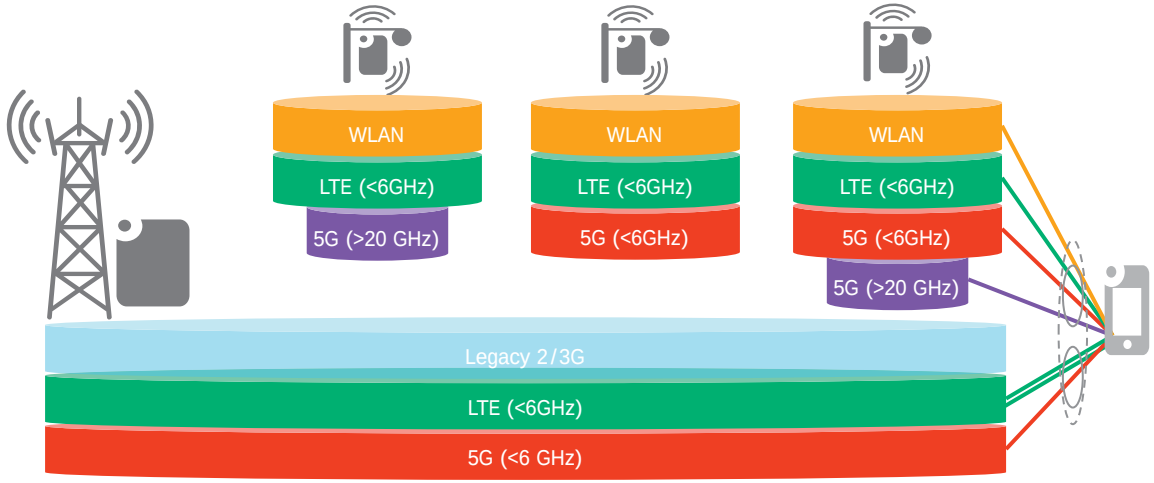


- "High band" (>20 GHz, known as mm-wave)
  - Enormous blocks of spectrum available for short range outdoor or indoor access
  - BUT should not plan to re-farm microwave backhaul bands
  - Will offer high peak bitrates for well placed users but will not significantly improve cell edge bitrates
  - Radio parameters may not be harmonised with low band systems (open issue)
- Expected to be used as a "secondary carrier"
  - Using Carrier Aggregation or Dual Connectivity
  - **While control plane and coverage ensured by "lower band" (<6 GHz) connection**

5G Radio: are we addressing the key drivers?

			5G	
Driver	**LTE Evolution**	**WLAN**	**Low band (< 6 GHz)**	**High band (>20 GHz)**
Mobile broadband	MIMO, HetNet and CoMP features	Multi-RAT and Boost	Higher spectrum efficiency	Peak bitrates Massive capacity
Innovative services	Capacity		Short packet Low latency	Scheduled low latency service
Crowds	Capacity	Capacity	Contention access	Massive capacity
Mission critical	Public safety features		Low latency	Scheduled low latency service
Battery life			Contention access	
Non traditional devices	MTC features (to bridge gap until 5G)	Short range access	Contention access	

5G Radio: Complements 4G and WLAN



MULTIPLE CARRIERS AND SITES

Combined using Carrier Aggregation and Dual Connectivity

Combining 5G, LTE and WLAN interfaces

5G (<6 GHz) on MACRO and SMALL CELL

- Coverage
- Connectionless service
- Low latency bearers
- Capacity

5G (>20 GHz) on SMALL CELL

- Massive Capacity
- Extreme low latency
- But unlikely to match lower band coverage

LTE EVOLUTION on MACRO and SMALL CELL

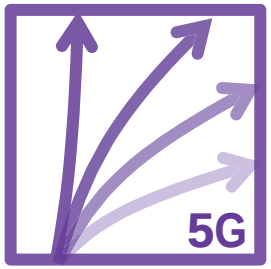
- Coverage for 4G
- Capacity for 4G and 5G
- Fallback coverage for 5G

WLAN on SMALL CELL

- Capacity for 5G and 4G
- Standalone service for any device

5G Radio: Macro and Small Cell layers, low and high bands plus LTE and WLAN

So: Why do we need a new & unified 5G radio interface?



- When we talk about M2M subscribers, these are not just devices. Applications on smartphones are already generating a large amount (30%) of short bursty traffic. Similarly M2M gateways using cellular uplink will contribute to the total amount of narrowband traffic. M2M subscribers = # devices × # applications/device

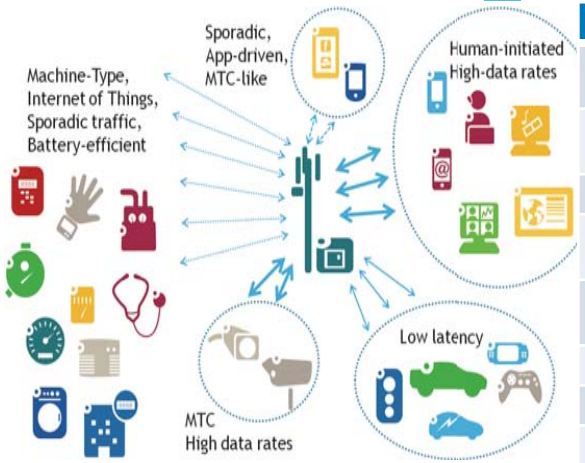
Ultra-broadband already acts as a channel for part of the ultra-narrowband traffic.

- The ultrabroadband track will require the integration of many different networks. In order to steer traffic quickly, seamlessly, without impacting the end-user, an efficient control system need to be present.

Efficient low latency narrowband communications benefit ultra-broadband as well.

5G Services: More complex requirements

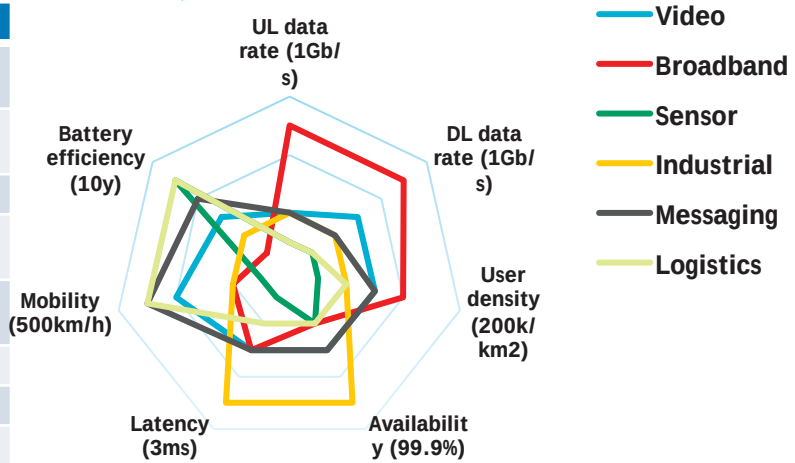
Device and service needs



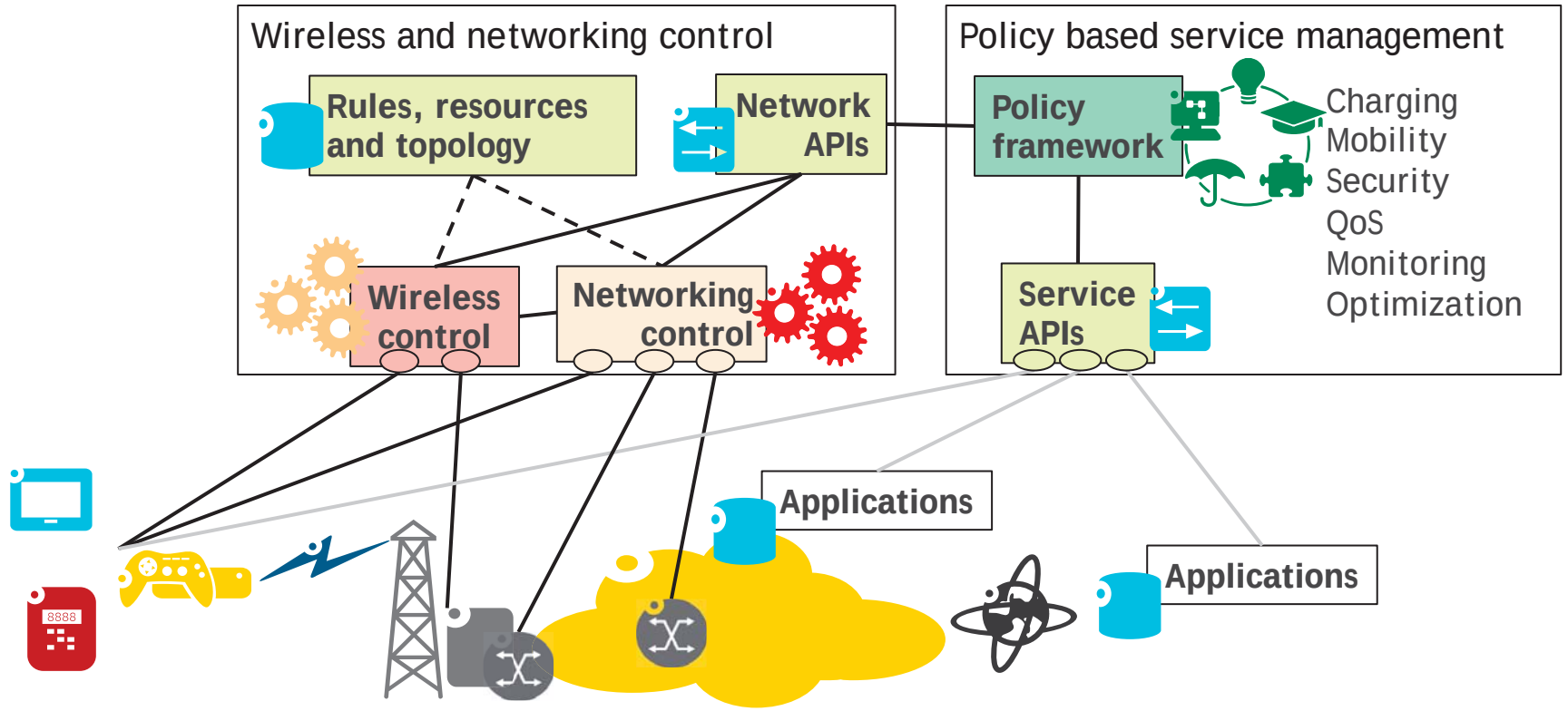
Abstraction

Richer Set of Service Options
Bitrate description GBR/N-GBR, peak, expected, sufficient
Latency (Packet delay): finer granulation, new **Low latency** option, average vs. first packet delay
Loss rate: finer granulation
Priority information (e.g. ARP): Availability class: best effort / prioritized
Activity: Background, streaming, very infrequent, etc.
Mobility category: fixed / nomadic /vehicular
Traffic type: Scheduled, Sporadic vs. Contention
UE power category: very low power (MTC), high power (WLL)
Security: Application privacy level, networking restrictions
Reliability: use case dependent
Networking: Routing restrictions, recommendations

Profiles & Configuration



5G Network: Policy based to adapt the network to the user



Defining 5G – What's involved?
5G Global activities – work on 5G have started

Global

- Next Generation Mobile Networks (NGMN): 5G project
- 3GPP: Study item proposals for Rel14, first specifications Rel15
- IEEE 802.11: Parallel evolution of Wi-Fi including mm-wave "WiGig"
- ITU-R: IMT-2020

Europe

- Multiple projects within FP7 including 5GNOW, METIS – EU
- 5G Infrastructure Public Private Partnership (5GPPP) - EU
- .. And 18 projects within FP8 starts mid 2015 – EU
- Universities: UK, Germany, Finland, etc.

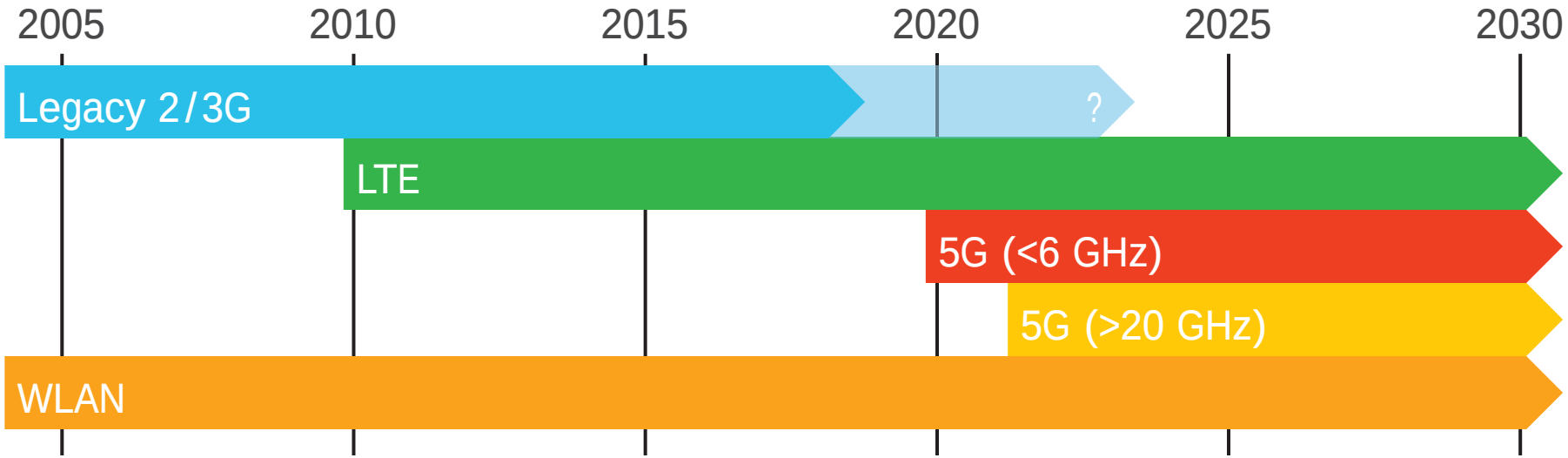
Asia

- IMT-2020 (5G) Promotion Group – *China*
- 5G Program (National 863 program) – *China*
- Korean 5G Forum - *Korea*
- 2020 and Beyond AdHoc – *Japan*
- Tokyo Institute of Technology and NTT docomo - *Japan*

Americas

- 4G Americas
- Universities: Polytechnic Institute of New York University, VA Tech – Broadband Wireless Access & Applications Center, Wireless@MIT Center
- Intel Strategic Research Alliance – *Academia & Industry*

Timing: LTE Evolves and 5G is coming



- LTE
  - Evolution continues well after 5G launch
- 5G
  - Low band deployed from 2020 first on macro cell then on small cells
  - High band on small cell follows as 5G capacity needed

Universal take-aways

ULTRA BROADBAND

ANTICIPATING 8X DATA GROWTH BY 2018 WITH PEAKS OF 20X FOR 25% OF SITES

MOBILE VIDEO & NEW APPS

LTE, WiFi & SMALL CELLS NEEDED TO ADDRESS CAPACITY/CONGESTION/QOE

MOVE TO CLOUD

NFV/SDN WILL DRIVE SCALE, LOWER COST, AND IMPROVE PERFORMANCE

DEDICATED HW → GPP PLATFORMS

THE NETWORK WILL BE INCREASINGLY VIRTUALIZED

5G ON THE HORIZON

UNDERSTAND WHAT THE SHIFT MAY BE AND HOW YOUR NETWORK FITS

USER CENTRIC NETWORKS

HAVE YOUR ARCHTECTURE READY, LOW BAND FIRST

ALL WILL BE NEEDED TO TACKLE THE OPPORTUNITY OF IOT AS WELL.

Every success has its network

Resources

- NGMN: http://www.ngmn.org/work-programme/5g-initiative.html
- GSMA: https://gsmaintelligence.com/research/?file=141208-5g.pdf&download
- ITU-R IMT-2020: http://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/default.aspx
- 3GPP: http://www.3gpp.org
- 5G-PPP: http://5g-ppp.eu
- Alcatel-Lucent: http://www.alcatel-lucent.com/solutions/lte-to-5G